ARMY RESEARCH LABORATORY

Data Transfer Report - 30-mm Enhanced Alternate High-Energy Propellant Program (EAHEP): Test Fixture and Propellant Evaluation

by Melvin B. Ridgley, Sr.,
and Joseph W. Colburn

ARL-SR-88 January 1999

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Data Transfer Report - 30-mm Enhanced Alternate High-Energy Propellant Program (EAHEP): Test Fixture and Propellant Evaluation

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Weapons and Materials Research Directorate, ARL

Abstract

Measurements in support of the 30-mm Enhanced Alternate High Energy Propellant Program (EAHEP) were taken at the Building 390 recording facility. Propellants evaluated for this series of tests were M30, U.S. Army Armament Research, Development, and Engineering Center (ARDEC) 7994, BAMO-AMMO/CL20, BAMO-AMMO/CL20/NQ, and BAMO-AMMO-RDX. This facility, the central data acquisition network for the Propulsion and Flight Division (PFD) of the U.S. Army Research Laboratory (ARL), was operated by the Experimental Ballistics Team (EBT) of the Propulsion Branch (PB). The testing was conducted in support of an ongoing Army effort to further investigate high-energy gun propellants that promise enhanced performance from existing tank and artillery systems.

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1. Background

Measurements in support of the 30-mm Enhanced Alternate High-Energy Propellant Program (EAHEP) were taken at the Building 390 recording facility. Propellants evaluated for this series of tests were M30, U.S. Army Armament Research, Development, and Engineering Center (ARDEC) 7994, BAMO-AMMO/CL20, BAMO-AMMO/CL20/NQ, and BAMO-AMMO-RDX. This facility, the central data acquisition network for the Propulsion and Flight Division (PFD) of the U.S. Army Research Laboratory (ARL), was operated by the Experimental Ballistics Team (EBT) of the Propulsion Branch (PB). The testing was conducted in support of an ongoing Army effort to further investigate high-energy gun propellants that promise enhanced performance from existing tank and artillery systems.

2. Test Objectives

The test objectives were to promote the evaluation of novel, high-energy gun propellants that promise enhanced performance from existing tank and artillery systems and to provide a facility that can assess the interior ballistic performance characteristics of small quantities of these propellants. Pertinent test information is detailed on the in-house branch firing request form, Appendix A. Test sample quantities, configurations, and data acquisition inputs were as requested by the project engineer. Appendix B shows a generalized gun configuration and pressure port locations, both in the chamber as well as in the barrel. In addition, it shows the range setup for the test. This report formally documents the data acquired during these tests for further use by the project engineer. Any technical information concerning the test setup or data should be solicited from the project engineer.

3. Summary of Results

A robust and easy-to-use test gun was required for the evaluation of small quantities (up to 125 g) of high-energy solid propellant samples. Due to funding constraints, a test gun was

designed based on available residual 30-mm hardware from a GT Devices (GTD)/General Dynamics Land Systems (GDLS) gun supplemented by existing ARL medium-caliber gun system components and several new parts. Unique features of the design include a simple dependable igniter system, which delivers a smooth ignition pulse to the experimental propelling charge; a robust chamber-tube seal system; and a ring-assisted stub case seal. These features permit safe, easy, and fast turnaround operations with the test gun. This report summarizes the data obtained during proof testing of the gun fixture and the initial propellant evaluation test series.

Experimental firing data and ignition system parameters are tabulated in Appendix C. The instrumentation typically used to acquire data during testing is as follows:

(1) In-bore doppler radar (35 GHz) to measure the interior ballistic trajectory.

(2) Discriminator system to measure projectile velocity.

(3) Kistler 607C3 piezoelectric pressure transducers in gauge positions as shown in Appendix B to measure chamber and barrel pressures.

(4) Downrange break screens to measure velocity.

Appendix D provides an example of a standard firing program file (FPF) that includes a Run Summary for the 30-mm EAHEP fixture and channel description/calibration coefficients for on-line and analog tape (A) for the EAHEP test rounds. Due to the number of rounds fired in this series, FPFs were not included for each round; however, Appendix E provides a summary of analog tape and digital acquisition system parameters. Twelve channels of data can be acquired on line using BALDAS II. It is standard procedure to back up the data on an analog tape recorder for future use or in case of computer malfunction.

4. Discussion and Results

Table 1 lists the test sequences with comments appropriate to instrumentation problems encountered for each test.

Table 1. Test Sequences and Accompanying Instrumentation Remarks

Test	Date	Comments
19	07 March 1996	EAHEP Gun 1 - M30 Propellant - good data
20	08 March 1996	EAHEP Gun 1 - M30 Propellant - P2L bad microdot cable
21	15 March 1996	EAHEP Gun 1 - M30 Propellant - good data
22	15 March 1996	EAHEP Gun 1 - M30 Propellant - good data
23	18 March 1996	EAHEP Gun 1 - M30 Propellant - good data
24	20 March 1996	EAHEP Gun 1 - M30 Propellant - good data
25	21 March 1996	EAHEP Gun 1 - M30 Propellant - good data
26	22 March 1996	EAHEP Gun 1 - M30 Propellant - good data
27	29 March 1996	EAHEP Gun 1 - Igniter tube integrity test
28	29 March 1996	EAHEP Gun 1 - 7994 ARDEC Propellant - good data
29	02 April 1996	EAHEP Gun 1 - 7994 ARDEC Propellant - good data
30	29 April 1996	EAHEP Gun 1 - 7994 ARDEC Propellant - good data
31	01 May 1996	EAHEP Gun 1 - 7994 ARDEC Propellant - good data
32	01 May 1996	EAHEP Gun 1 - 7994 ARDEC Propellant - good data
33	01 May 1996	EAHEP Gun 1 - 7994 ARDEC Propellant - good data
34	01 May 1996	EAHEP Gun 1 - 7994 ARDEC Propellant - good data
35	22 January 1997	EAHEP Gun 1 - M30 Propellant - good data
36	01 February 1997	EAHEP Gun 1 - M30 Propellant - good data
39	13 February 1997	EAHEP Gun 1 - B-A/RDX Propellant - Bad microdot cable, Barrel 3

During testing, the Building 390 recording room staff made the following specific contributions beyond the recording of data:

- Assisted with building and testing a different method for checking out break screens.

- When the signal from the discriminator seemed to drop out during test rounds 20, 22, 23, 25, and 26, traced the problem to an intermittent component on the frequency board and repaired it.
- Gave all ballistic data in the form of floppy disks (ASCII format), data plots, and FPFs to the project engineer at the conclusion of each test.

Appendix A:

Experimental Ballistics Team Firing Request

EXPERIMENTAL BALLISTICS TEAM FIRING REQUEST

BRANCH REQUEST: Advanced Propulsion Physics Branch

CONTRACTOR REQUEST: N/A

PROJECT TITLE: EAHEP Test Fixture and Propellant Evaluation

PROJECT ENGINEERS: J. Colburn, A. A. Juhasz, and A. Johnson

PURPOSE OF TEST: To promote the evaluation of novel, high-energy gun propellants that promise enhanced performance from existing tank and artillery systems. To provide a facility that can assess the interior ballistic performance characteristics of small quantities of these propellants.

TIME FRAME REQUEST: LENGTH OF TEST - 7 March 1996 to 13 February 1997
(Days and number of rounds): 16 Days, 21 Rounds

RANGE REQUIREMENTS:

GUN TYPE: 30-mm GDLS ETC

PROJECTILE TYPE: Slug

CHARGE TYPE:

PRIMER TYPE: M52

GUN INSTRUMENTATION: Pressure gauges in chamber and barrel.

RANGE INSTRUMENTATION:

- Interferometer
- Discriminator/Velocity
- Video/Audio
- Break Screens

INTERIOR BALLISTICIAN:

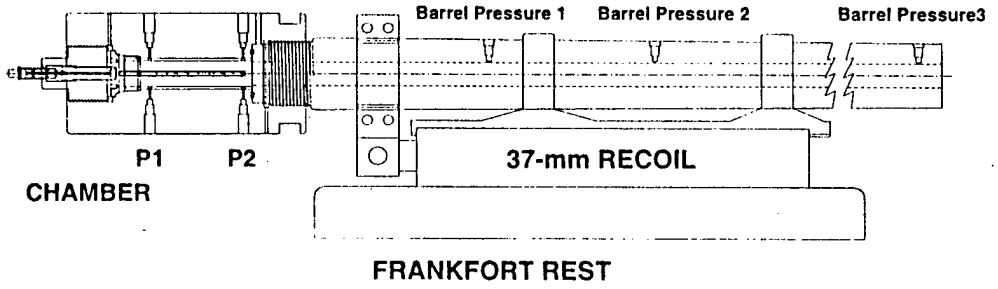
REVIEW OF TEST PLAN: A. A. Juhasz

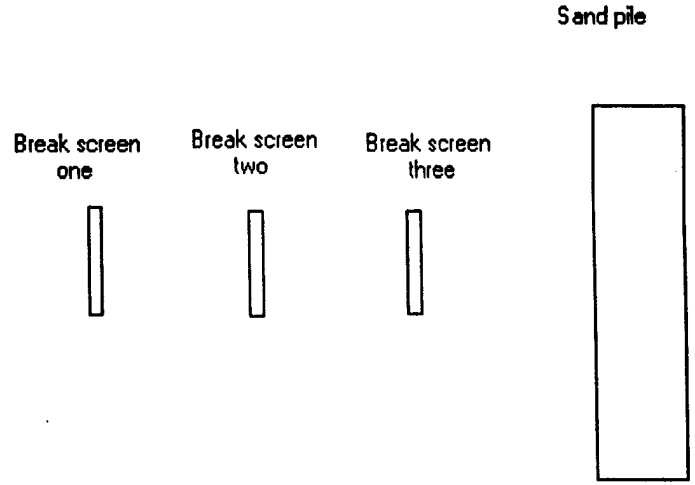
OTHER REQUIREMENTS: As outlined by project engineer.

Appendix B:

Gauge Locations and Range Setup for the 30-mm Gun

EAHEP 30-mm Gauge Locations and Range Setup





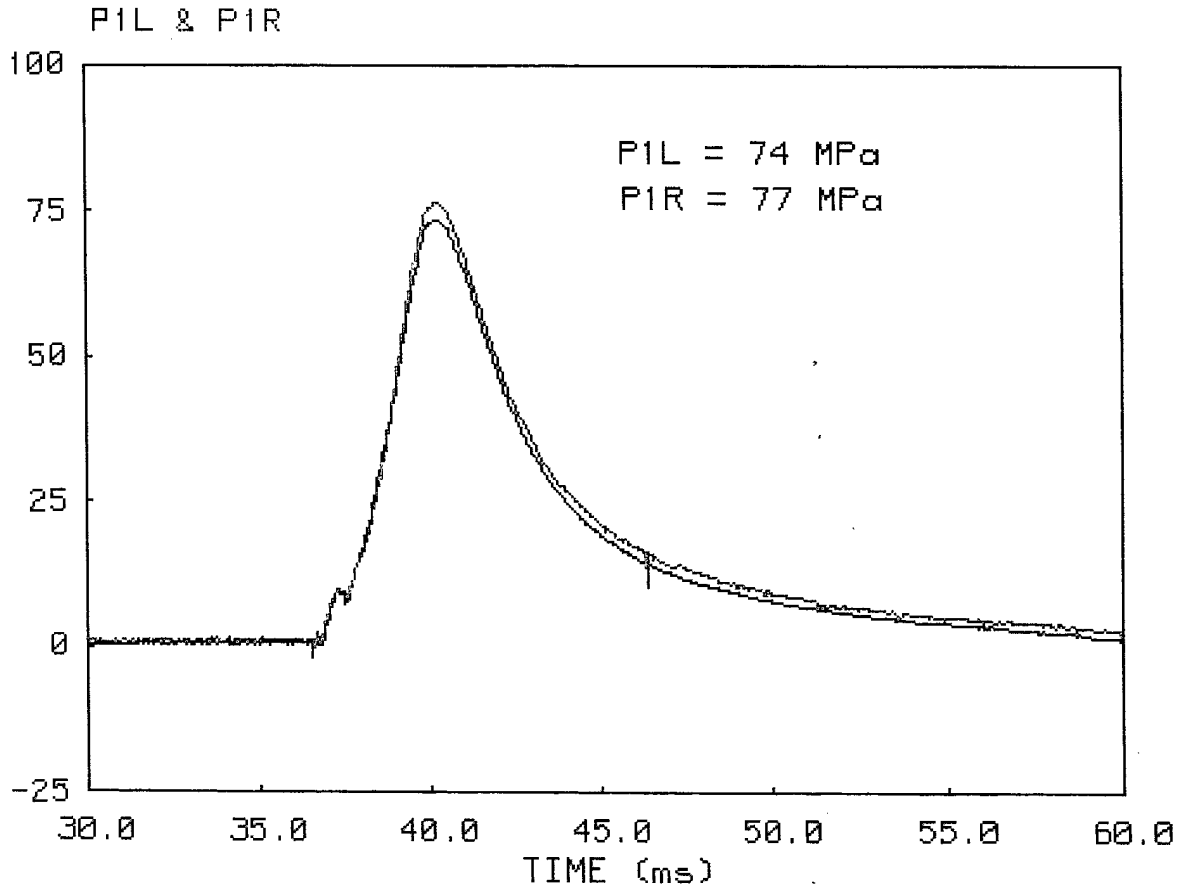
Appendix C:

Tabular Data and Example of Experimental Firing Data

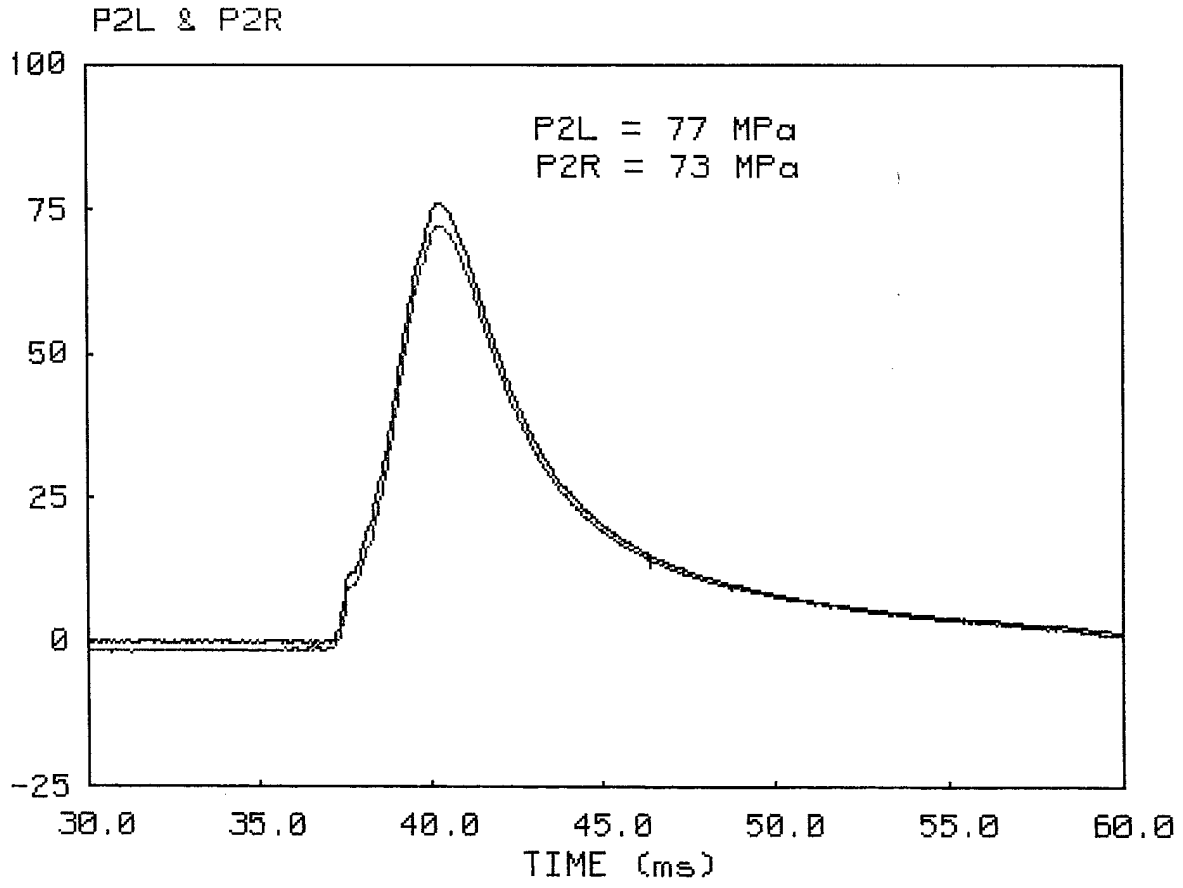
Tabular Data

Test No.	Peak, Quasi-Static Pressure (MPa)							
	P1 Left	P1 Right	P2 Left	P2 Right	Barrel 1	Barrel 2	Barrel 3	35 GHz m/s
19	84.4	86	77.7	81.2	75.9	64.2	17.1	875
20	90.7	91.3		85	81	71.2	15	—
21	154	159	148	151	143	131	20	1047
22	209	215	192	203	177	158	29	—
23	209	247	227	234	207	180	23	—
24	326	330	310	315	273	224	24	1402
25	392	422	313	398	335	312	40	—
26	377	390	374	381	328	313	34	—
27	Igniter	Tube	Integrity	Test	—	—	—	—
28	99	103	97	98	93	88	16	970
29	94.4	103.8	98	99	94.5	87	18	971
30	166	169	164	168	157	156	27	910
31	388	411	379	407	376	316	31	—
32	390	411	387	396	374	318	29	1216
33	394	—	386	397	380	337	31	1185
34	396	411	403	394	376	331	32	1234
35	330	325	318	324	309	230	22	936
36	318	307	310	304	298	224	21	926
37	169	164	164	161	166	136	16	721
38	134	133	133	127	136	102	12	399
39	74	77	77	73	81	53	—	240

13 FEB 1997 EAHEP Round 39 P1L P1R



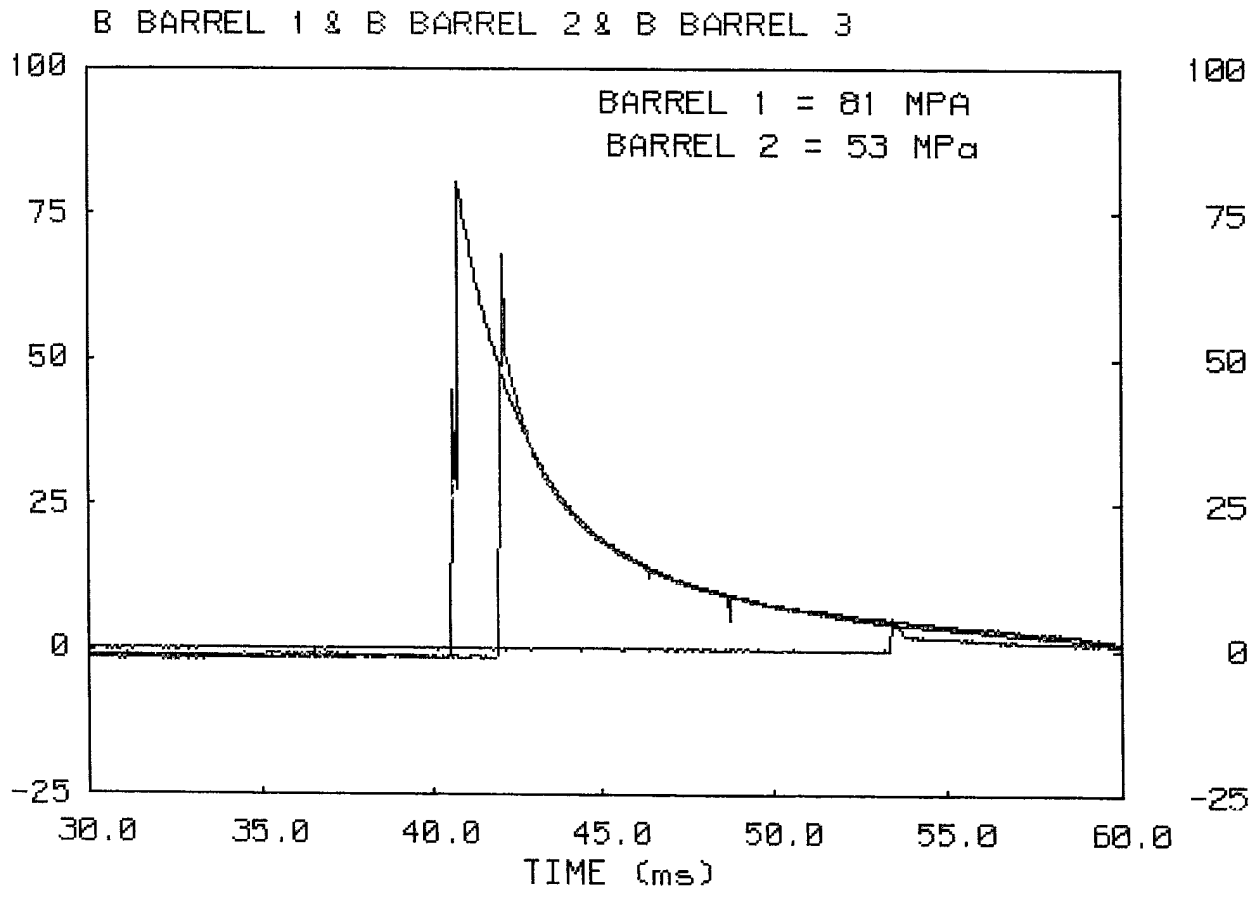
13 FEB 1997 EAHEP Round 39 P2L P2R



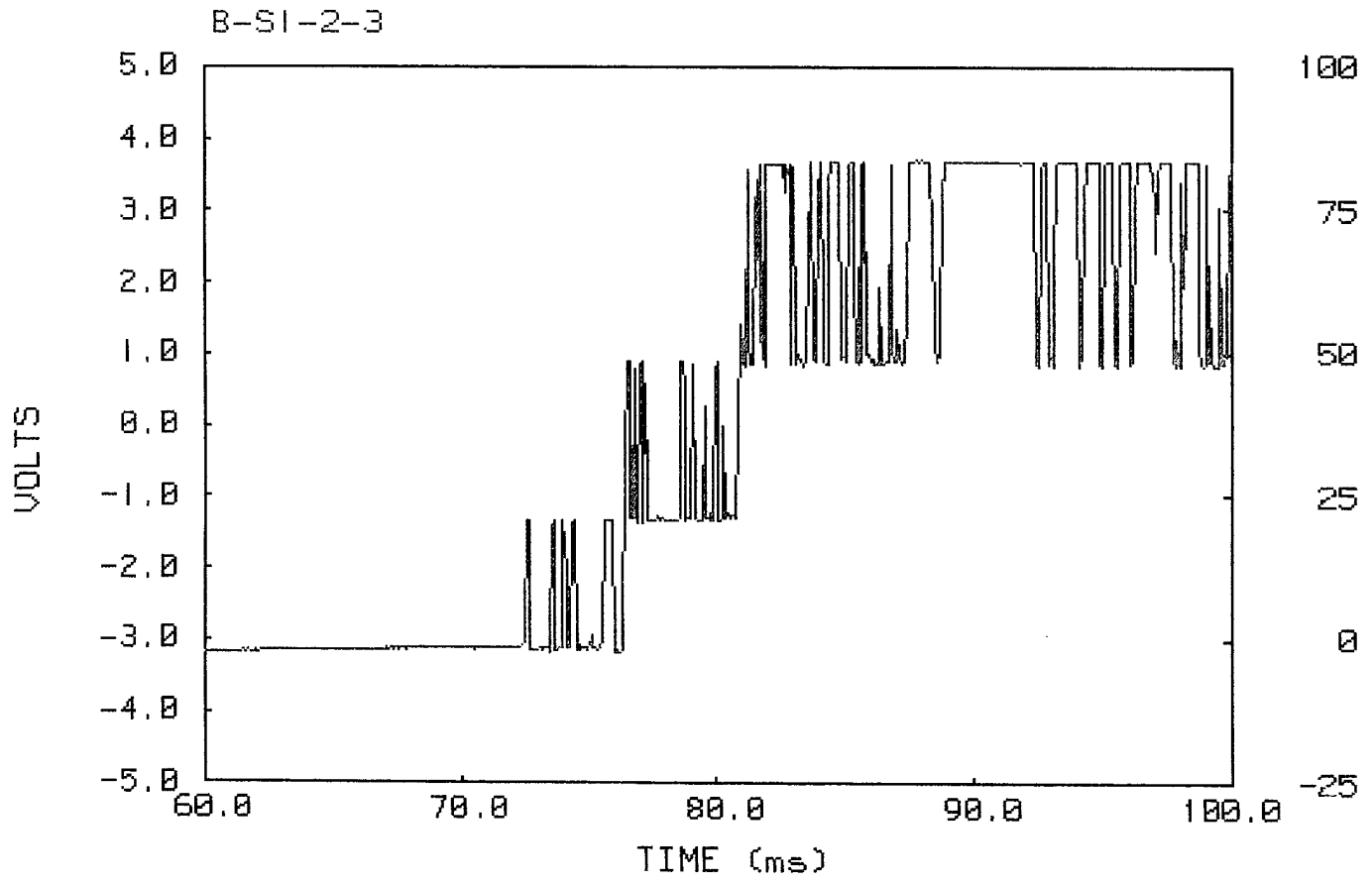
13 FEB 1997

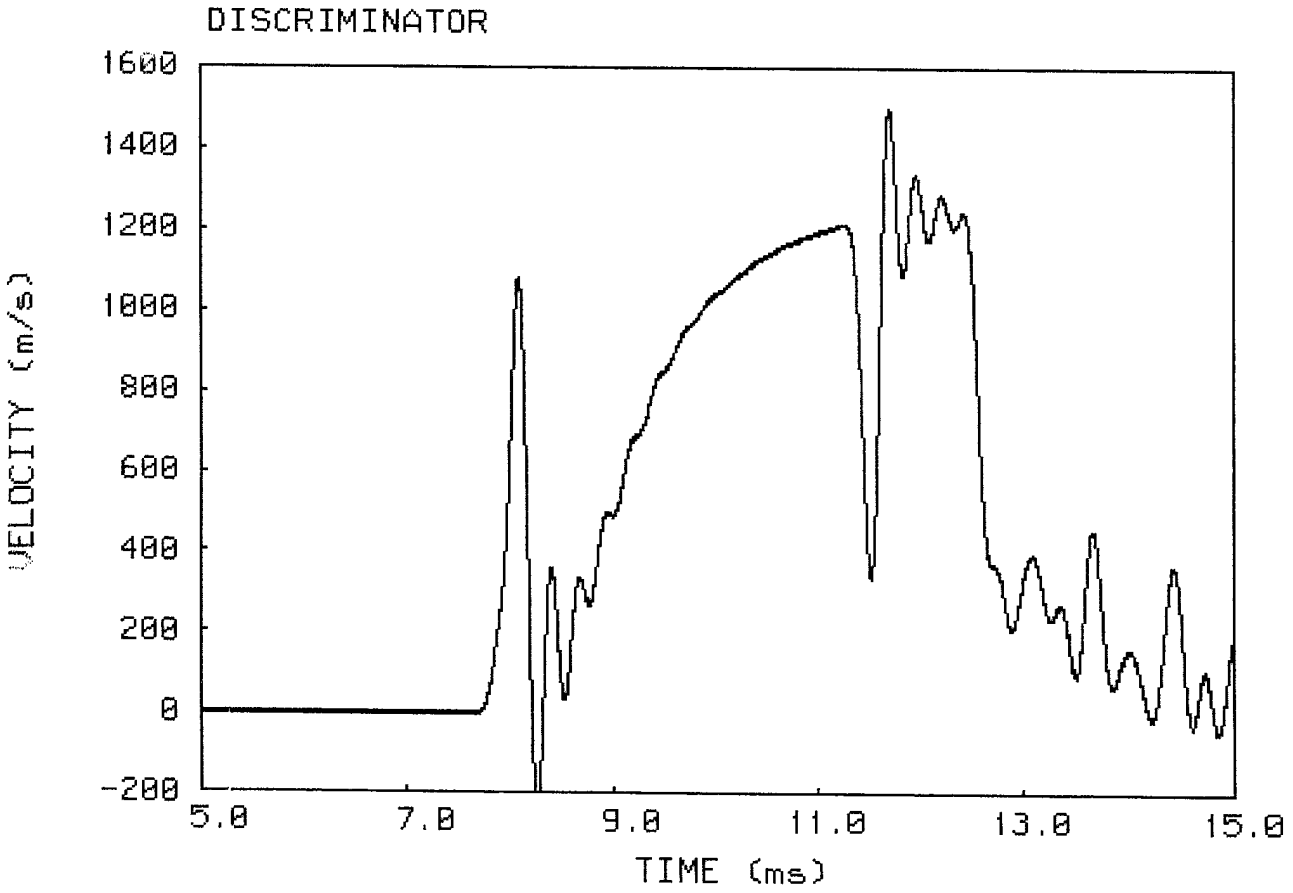
EAHEP Round 39

B BARREL
B BARREL
B BARREL



13 FEB 1997 EAHEP Round 39 B-S1-2-3

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1400
1200
1000
800
600
400
200
0
-200
VELOCITY (m/s)
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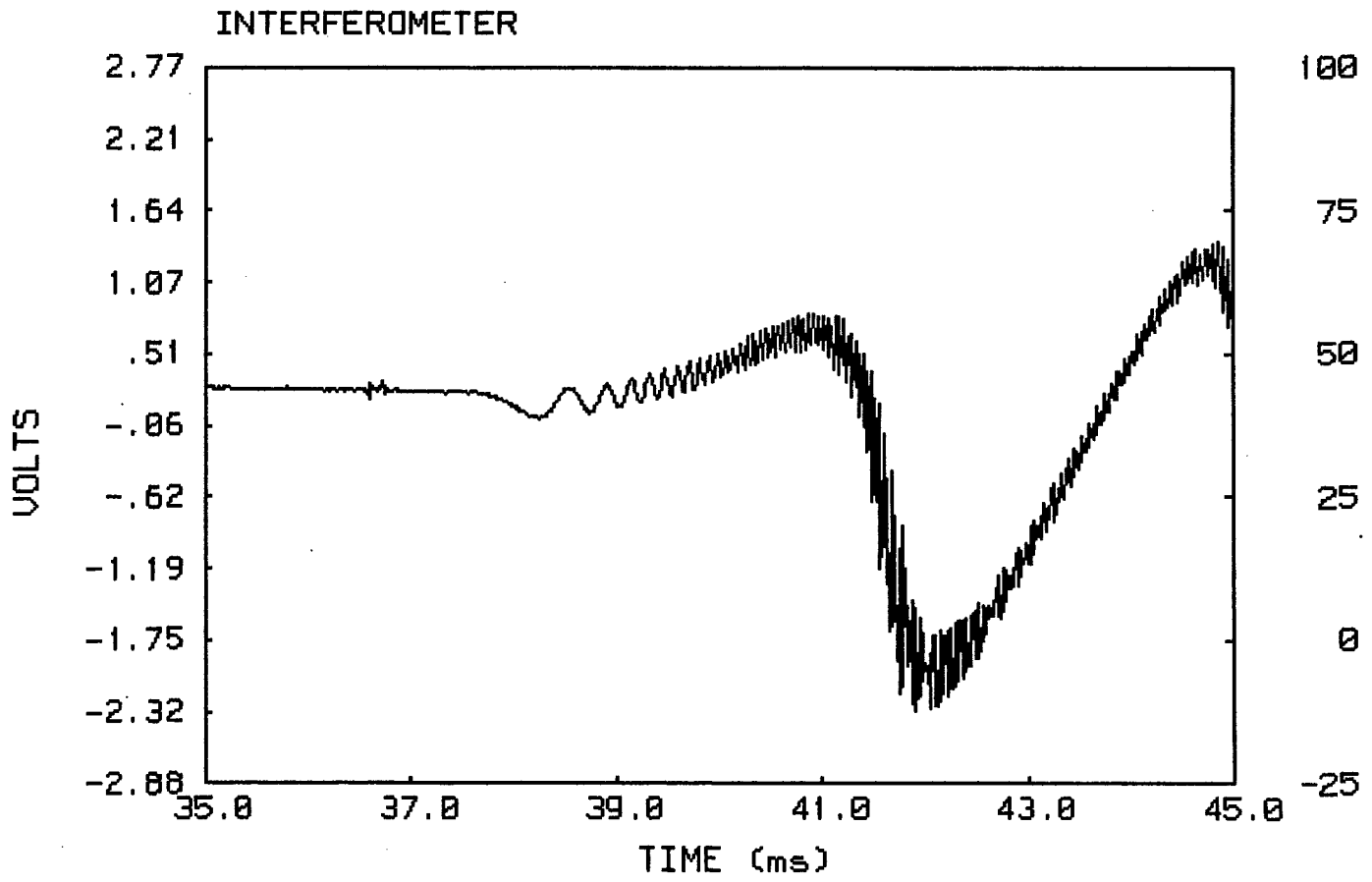
7.0
9.0
11.0
13.0
15.0
TIME (ms)

13 FEB 1997 EAHEP Round 39 INTERFERO



Appendix D:

Examples of Run Summary and Channel Description/Calibration Coefficients On Line for the 30-mm EAHEP

RUN SUMMARY FOR EAHEP - EAP ROUND 39

TEST DATA

DATE	: 13 FEB 1997	ENGINEER	: COLBURN
LOCATION	: R 166	OPERATOR	: MBR
CLEARANCE	: X	GUNNERS	: COLBURN

ANALOG TAPE PARAMETERS

REEL NUMBER	: 487	IDENT NUMBER	: 32
STATUS	: ON	SPEED CODE	: 120
START	: 5885		
STOP	:		

ENVIRONMENT

TEMPERATURE	: 20 C	DENSITY	: g/ml
BAROMETER	: mm Hg	WIND SPEED	: m/s
HUMIDITY	: %	WIND DIRECTION	: Deg

GUN DATA

TUBE	: EAHEP-1	CALIBERS/TURN	: 999999
NUMBER	: SN 529	GROOVE DIAMETER	: 29.21 mm
TUBE ROUND NUMBER	: 0	LAND DIAMETER	: 29.21 mm
TRAVEL	: 2670 mm	GROOVE/LAND RATIO	: 1
CHAMBER VOLUME	: 121.66 cc		

REMARKS : 529 USED PREV BY TBD

MOUNT

RECOIL TYPE	: 37-MM	MOUNT TYPE	: UNKNOWN
RECOIL SERIAL NUMBER	: UNKNOWN	MOUNT SERIAL NUMBER	: UNKNOWN
ELEVATION	: 0 mils	AZIMUTH	: 0 mils

REMARKS : BLUE MOUNT & RECOIL

PROJECTILE

TYPE	: MILD STEEL SLUG	BAND TYPE	: POLYPROPULUX
LOT NUMBER	: 2	BAND DIAMETER	: N/A mm
WEIGHT	: .305kg	BAND WIDTH	: N/A mm
FILL	: SOLID	FUZE	: N/A
PROJECTILE TEMP	: AMBIENT C		

REMARKS : TYPE 2 SLUG AND OBTURATOR

PRIMER

PRIMER TYPE	: M52 A3 B1	WEIGHT	: N/Ag
LOT NUMBER	: LC-20-625	TEMPERATURE	: AMBIENT C

REMARKS : 200V FIRING VOLTAGE

IGNITER

IGNITER TYPE	: BENITE	WEIGHT	: 1.5g
LOT NUMBER	:	TEMPERATURE	: AMBIENT C

REMARKS : USING BAYONETTE IGNITER TUBE

ADC 1

CHANNEL SIZE: 20 KBytes
TIME PER SAMPLE: .005 ms
MUX POSITION: 2

CHANNELS: 12
PRETRIGGER SIZE: 1/8
TRIGGER LEVEL: 2 Volts

CHANNEL	GAGE DESCRIPTION	CALIBRATION COEFFICIENTS
1	P1L KISTLER 607C3/C55333 Top step: 8	Constant : 4.4036E-01 Linear : 58.310 Quadratic: -3.2210E-01
2	P1R KISTLER 607C3/C54587 Top step: 8	Constant : 7.7135E-01 Linear : 61.052 Quadratic: -4.0050E-01
3	P2L KISTLER 607C3/C47191 Top step: 8	Constant : 1.4745E-01 Linear : 58.751 Quadratic: -3.3017E-01
4	P2R KISTLER 607C3/C55334 Top step: 8	Constant : -6.7238E-02 Linear : 57.788 Quadratic: -3.2828E-01
5	BARREL 1 KISTLER 607C3/C55331 Top step: 8	Constant : -1.1027E-01 Linear : 58.986 Quadratic: -4.7070E-01
6	BARREL 2 KISTLER 607C3/C55332 Top step: 8	Constant : 1.4386E-01 Linear : 57.344 Quadratic: -3.4921E-01
7	BARREL 3 KISTLER 607C3/C57305 Top step: 1	Constant : 1.2304E+00 Linear : 54.446 Quadratic: -1.4959E-01
8	FR FIRING VOLTAGE	NOT CALIBRATED
9	B-S1-2-3 BS COMMON OUTPUT	NOT CALIBRATED
10	NOT USED NOT USED	NOT CALIBRATED
11	DISCRIMINATOR 35 GHz Top step: 5	Constant : 0 Linear : 259.92 Quadratic: 0
12	INTERFEROMETER 35 GHz	NOT CALIBRATED

CHARGE

CHARGE TYPE	: M30	ZONE	: RAD-PE-771-2
LOT NUMBER	: N/A	TEMPERATURE	: AMBIENT C

REMARKS : 7-PERF M30 .0125 WEB

CASE

CASE TYPE	: LEXAN	LOT NUMBER	: 1

REMARKS : .125" THICK

LOADING

SEATING DISTANCE	: mm	CHARGE STANDOFF	: mm

REMARKS :

EAP Rd 39

PROPELLANTS NUMBER OF PROPELLANTS: 1

PROPELLANT 1

PROPELLANT TYPE	:		PERF DIAMETER	:	
LOT NUMBER	:		TEMPERATURE	:	C
WEIGHT	:	kg	IMPETUS	:	J/kg
INNER WEB	:	mm	SPECIFIC HEAT RATIO	:	
OUTER WEB	:	mm	FLAME TEMPERATURE	:	K
LENGTH	:	mm	COVOLUME	:	cc/g
DIAMETER	:	mm	DENSITY	:	g/cc

REMARKS :

EAP Rd 39

VELOCITY

VELOCITY DEVICE: HP COUNTER

DISTANCE 1: 1.0025 m
ETS CHANNEL: 1 VELOCITY 1-2 256.886611147 m/s
DISTANCE 2: 1.062 m
ETS CHANNEL: 2 VELOCITY 2-3 241.182749302 m/s
DISTANCE 3: 2.0645 m
ETS CHANNEL: 3 VELOCITY 1-3 248.582196482 m/s

EVENT TIMER

ETS CLOCK RATE CODE: CHANNELS: 6

CHANNEL	DESCRIPTION	TIME (s)
1		+3.9025E-03
2		+4.4033E-03
3		+8.3051E-03
4		
5		
6		

TEST REMARKS

ONLINE DATA

Appendix E:

Analog Tape and Digital Acquisition System Parameters

Analog Tape and Digital Acquisition System Parameters

Round	Analog Tape	Identification	Start Footage	Tape Speed	Digital Sampling Rate		Channels	Channel Size	
			A		On Line (ms)	Tape Digitization (μs)	On Line/Tape Digitization	On Line	Digitized
19	487	12	1635–1750	120	.005	2.5	12	20,000	16,000
20	487	13	3725–3840	120	.005	2.5	12	20,000	16,000
21	487	14	3840–3960	120	.005	2.5	12	20,000	16,000
22	487	15	3960–4070	120	.005	2.5	12	20,000	16,000
23	487	16	4115–4245	120	.005	2.5	12	20,000	16,000
24	487	17	4245–4353	120	.005	2.5	12	20,000	16,000
25	487	18	4353–4450	120	.005	2.5	12	20,000	16,000
26	487	19	4450–4545	120	.005	2.5	12	20,000	16,000
27	487	20	4700–4860	120	.005	2.5	12	20,000	16,000
28	487	21	4860–4975	120	.005	2.5	12	20,000	16,000
29	487	22	4975–5075	120	.005	2.5	12	20,000	16,000
30	487	23	5075–5180	120	.005	2.5	12	20,000	16,000
31	487	24	5180–5275	120	.005	2.5	12	20,000	16,000
32	487	25	5275–5390	120	.005	2.5	12	20,000	16,000
33	487	26	5390–5485	120	.005	2.5	12	20,000	16,000
34	487	27	5485–5575	120	.005	2.5	12	20,000	16,000
35	487	28	5575–5656	120	.005	2.5	12	20,000	16,000
36	487	29	5656–5735	120	.005	2.5	12	20,000	16,000
37	487	30	5735–5810	120	.005	2.5	12	20,000	16,000
38	487	31	5810–5858	120	.005	2.5	12	20,000	16,000
39	487	32	5885–5965	120	.005	2.5	12	20,000	16,000

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